APPENDIX A

BOARD APPOINTMENT MEMORANDUM

The Secretary of Energy
Washington, DC 20585

March 21, 2000

MEMORANDUM FOR: RICHARD E. GLASS, MANAGER
ALBUQUERQUE OPERATIONS OFFICE

FROM: BILL RICHARDSON

SUBJECT: Type A Accident Investigation of the
March 16, 2000, Radiological Event at TA-55,
Los Alamos National Laboratory

I hereby establish a Type A Accident Investigation Board to investigate the March 16, 2000, radiological contamination and intake event at Technical Area 55, Los Alamos National Laboratory. I have determined that it meets the requirements for a Type A investigation consistent with DOE Order 225.1A, *Accident Investigations.*

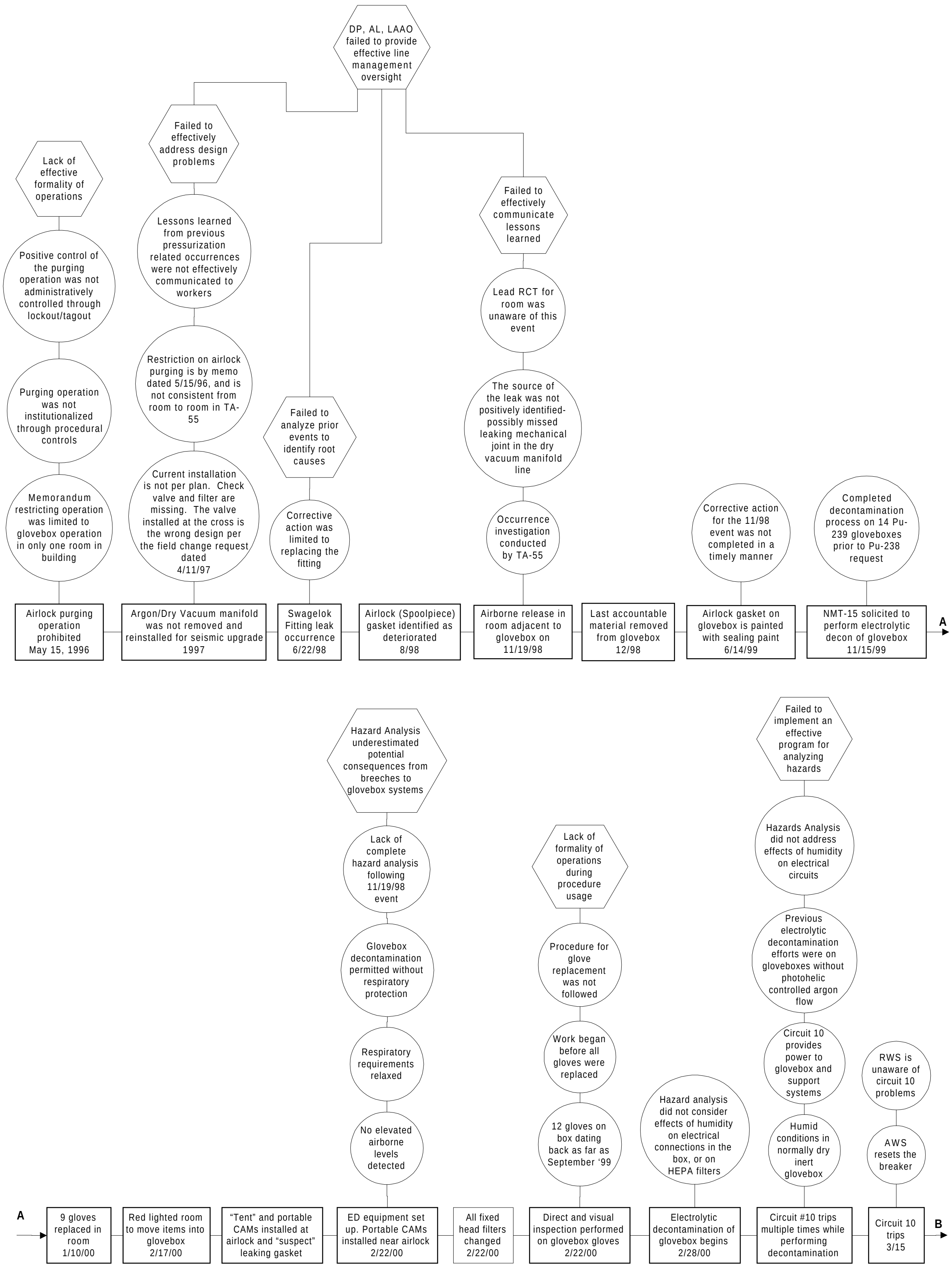
The Office of Oversight within the Office of Environment, Safety and Health will lead the investigation. I appoint Thomas Rollow as the Accident Investigation Board Chairperson from the Office of Oversight. The Board will be composed of the following members: Peter O'Connell, Worker Protection Programs and Hazards Management; Douglas Minnema, Defense Programs; Ali Ghovanlou, Independent Oversight Performance Assurance; John Eschenberg, Savannah River Operations Office; Michael Cornell, Oakland Operations Office; and Isaac Valdez, Albuquerque Operations Office. I have been assured that these individuals do not have "direct line management responsibility for day-to-day operation or oversight of the facility, area, or activity involved in the accident." The Board will be assisted by advisors and other personnel as deemed necessary by the Board Chairperson.

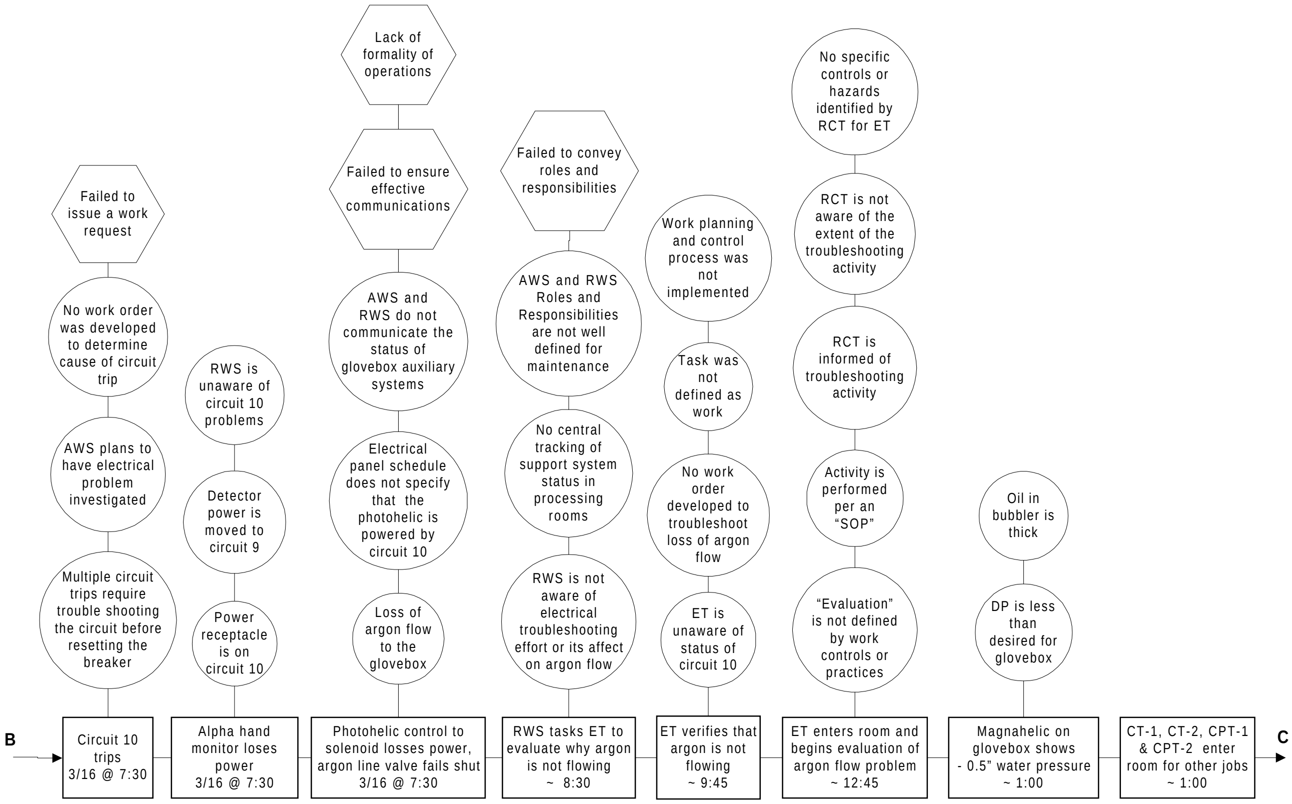
The scope of the Board's investigation will include, but is not limited to, analyzing causal factors, identifying root causes resulting in the accident, and determining Judgments of Need to prevent recurrence. The investigation will be conducted in accordance with DOE Order 225.1A. The Board will examine safety management systems, including management roles and responsibilities and application of lessons learned from similar type accidents within the Department. The investigation and analyses will be conducted within the framework of the Department's Integrated Safety Management Policy to assure maximum benefit to improving safety and sharing lessons learned throughout the complex.

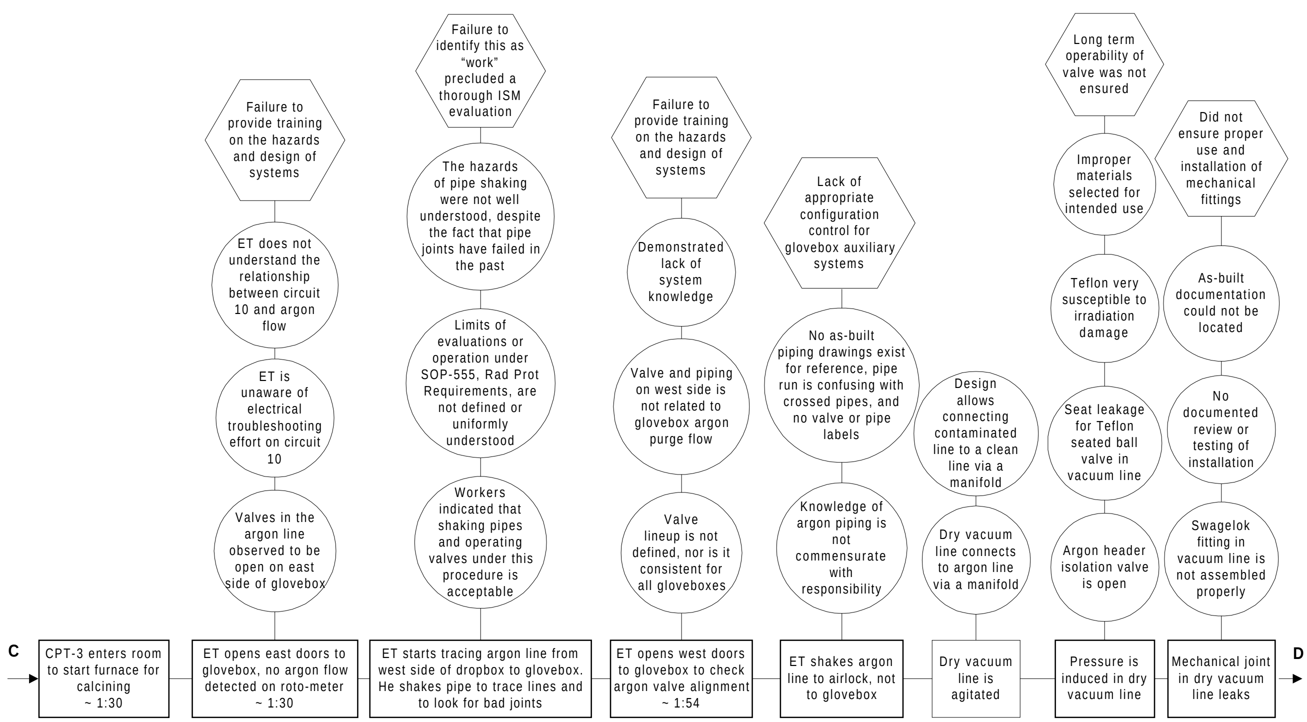
The Board will provide the Assistant Secretary for Environment, Safety and Health with periodic reports on the status and progress of the investigation. These reports should not include any findings or arrive at any premature conclusions until an analysis of all the causal factors have been completed. Discussions of the investigation and copies of the draft report will be controlled until I accept and authorize release of the final report. The final report should be provided to my office by April 21, 2000.

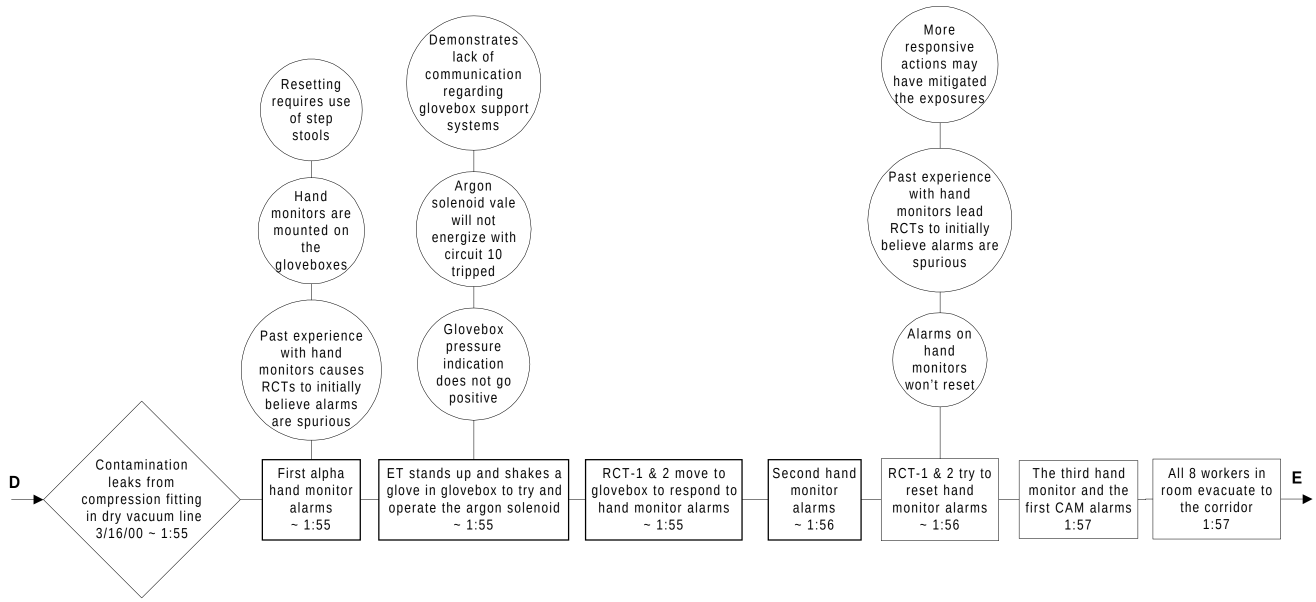
cc:
T.J. Glauthier, DS
D. Michaels, EH-1
T. Rollow, EH-2
S. David Stadler, EH-2
R. Hardwick, EH-2
J. Fitzgerald, EH-5
T. Gioconda DP-1
G. Podonsky, OA-1
G. Rudy, SR
J. Turner, OAK
C. Longenbaugh, AL AI POC

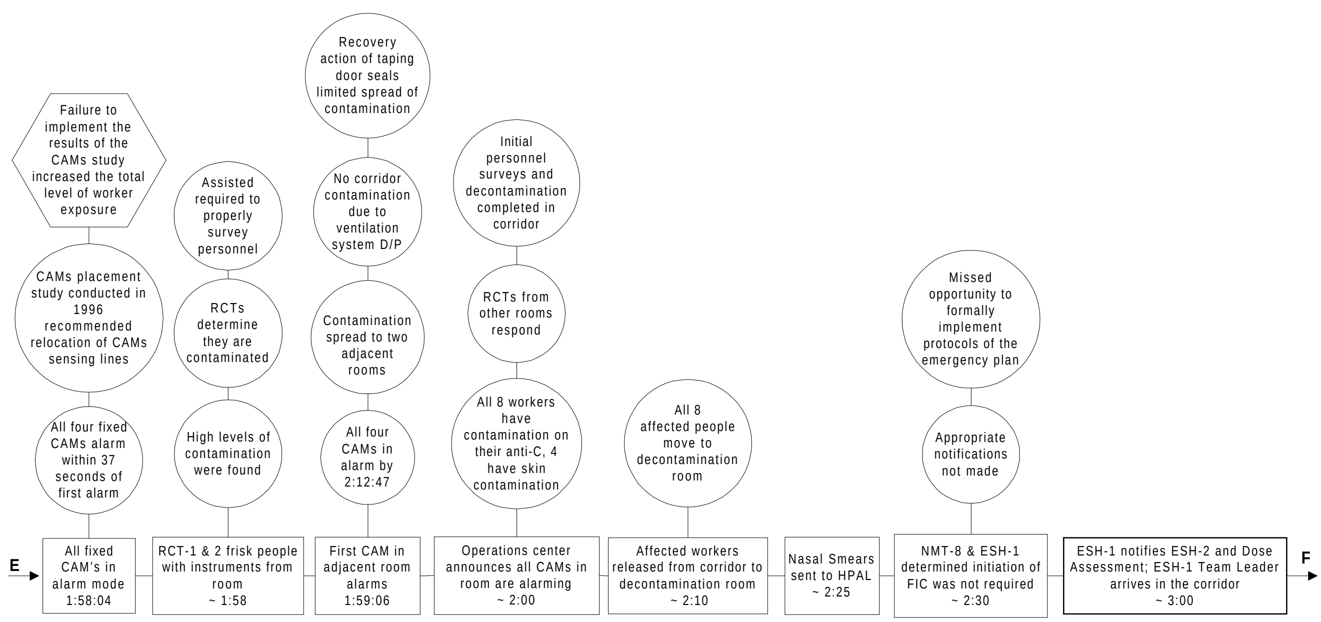
APPENDIX B
EVENTS AND CAUSAL FACTORS CHART

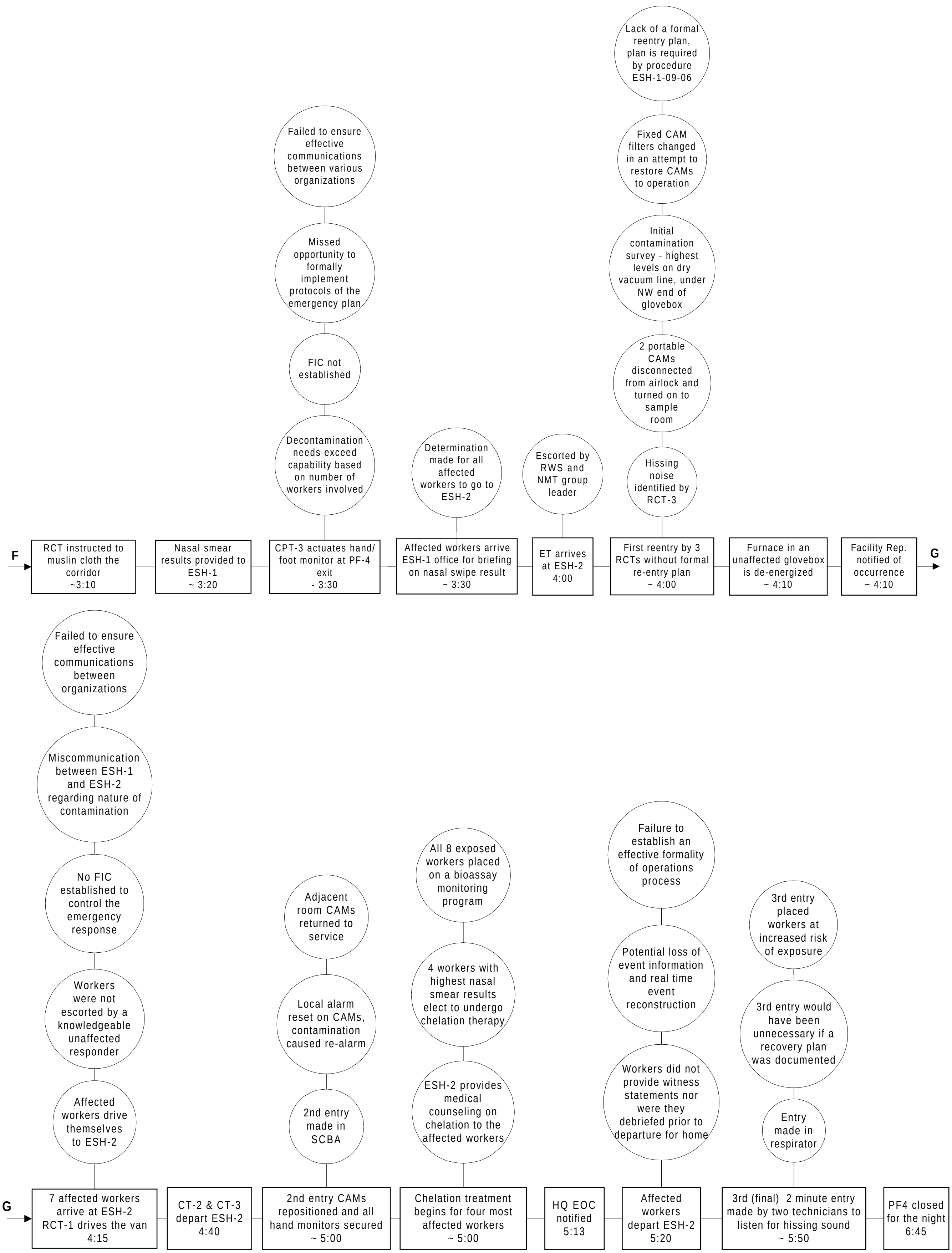



B
Failed to issue a work request
No work order was developed to determine cause of circuit trip
AWS plans to have electrical problem investigated
Multiple circuit trips require trouble shooting the circuit before resetting the breaker
Circuit 10 trips 3/16 @ 7:30
RWS is unaware of circuit 10 problems
Detector power is moved to circuit 9
Power receptacle is on circuit 10
Alpha hand monitor loses power 3/16 @ 7:30
Lack of formality of operations
Failed to ensure effective communications
AWS and RWS do not communicate the status of glovebox auxiliary systems
Electrical panel schedule does not specify that the photohelic is powered by circuit 10
Loss of argon flow to the glovebox
Photohelic control to solenoid losses power, argon line valve fails shut 3/16 @ 7:30
Failed to convey roles and responsibilities
AWS and RWS Roles and Responsibilities are not well defined for maintenance
No central tracking of support system status in processing rooms
RWS is not aware of electrical troubleshooting effort or its affect on argon flow
RWS tasks ET to evaluate why argon is not flowing ~ 8:30
Work planning and control process was not implemented
Task was not defined as work
No work order developed to troubleshoot loss of argon flow
ET is unaware of status of circuit 10
ET verifies that argon is not flowing ~ 9:45
No specific controls or hazards identified by RCT for ET
RCT is not aware of the extent of the troubleshooting activity
RCT is informed of troubleshooting activity
Activity is performed per an “SOP”
“Evaluation” is not defined by work controls or practices
ET enters room and begins evaluation of argon flow problem ~ 12:45
Oil in bubbler is thick
DP is less than desired for glovebox
Magnahelic on glovebox shows - 0.5” water pressure ~ 1:00
CT-1, CT-2, CPT-1 & CPT-2 enter room for other jobs ~ 1:00
C


C
CPT-3 enters room to start furnace for calcining ~ 1:30
Failure to provide training on the hazards and design of systems
ET does not understand the relationship between circuit 10 and argon flow
ET is unaware of electrical troubleshooting effort on circuit 10
Valves in the argon line observed to be open on east side of glovebox
ET opens east doors to glovebox, no argon flow detected on roto-meter ~ 1:30
Failure to identify this as “work” precluded a thorough ISM evaluation
The hazards of pipe shaking were not well understood, despite the fact that pipe joints have failed in the past
Limits of evaluations or operation under SOP-555, Rad Prot Requirements, are not defined or uniformly understood
Workers indicated that shaking pipes and operating valves under this procedure is acceptable
ET starts tracing argon line from west side of dropbox to glovebox. He shakes pipe to trace lines and to look for bad joints
Failure to provide training on the hazards and design of systems
Demonstrated lack of system knowledge
Valve and piping on west side is not related to glovebox argon purge flow
Valve lineup is not defined, nor is it consistent for all gloveboxes
ET opens west doors to glovebox to check argon valve alignment ~ 1:54
Lack of appropriate configuration control for glovebox auxiliary systems
No as-built piping drawings exist for reference, pipe run is confusing with crossed pipes, and no valve or pipe labels
Knowledge of argon piping is not commensurate with responsibility
ET shakes argon line to airlock, not to glovebox
Design allows connecting contaminated line to a clean line via a manifold
Dry vacuum line connects to argon line via a manifold
Dry vacuum line is agitated
Long term operability of valve was not ensured
Improper materials selected for intended use
Teflon very susceptible to irradiation damage
Seat leakage for Teflon seated ball valve in vacuum line
Argon header isolation valve is open
Pressure is induced in dry vacuum line
Did not ensure proper use and installation of mechanical fittings
As-built documentation could not be located
No documented review or testing of installation
Swagelok fitting in vacuum line is not assembled properly
Mechanical joint in dry vacuum line leaks
D


Resetting requires use of step stools
Hand monitors are mounted on the gloveboxes
Past experience with hand monitors causes RCTs to initially believe alarms are spurious
Demonstrates lack of communication regarding glovebox support systems
Argon solenoid vale will not energize with circuit 10 tripped
Glovebox pressure indication does not go positive
More responsive actions may have mitigated the exposures
Past experience with hand monitors lead RCTs to initially believe alarms are spurious
Alarms on hand monitors won't reset
D
Contamination leaks from compression fitting in dry vacuum line 3/16/00 ~ 1:55
First alpha hand monitor alarms ~ 1:55
ET stands up and shakes a glove in glovebox to try and operate the argon solenoid ~ 1:55
RCT-1 & 2 move to glovebox to respond to hand monitor alarms ~ 1:55
Second hand monitor alarms ~ 1:56
RCT-1 & 2 try to reset hand monitor alarms ~ 1:56
The third hand monitor and the first CAM alarms 1:57
All 8 workers in room evacuate to the corridor 1:57
E


Failure to implement the results of the CAMs study increased the total level of worker exposure
CAMs placement study conducted in 1996 recommended relocation of CAMs sensing lines
All four fixed CAMs alarm within 37 seconds of first alarm
Assisted required to properly survey personnel
RCTs determine they are contaminated
High levels of contamination were found
Recovery action of taping door seals limited spread of contamination
No corridor contamination due to ventilation system D/P
Contamination spread to two adjacent rooms
All four CAMs in alarm by 2:12:47
Initial personnel surveys and decontamination completed in corridor
RCTs from other rooms respond
All 8 workers have contamination on their anti-C, 4 have skin contamination
All 8 affected people move to decontamination room
Missed opportunity to formally implement protocols of the emergency plan
Appropriate notifications not made
E
All fixed CAM's in alarm mode 1:58:04
RCT-1 & 2 frisk people with instruments from room ~ 1:58
First CAM in adjacent room alarms 1:59:06
Operations center announces all CAMs in room are alarming ~ 2:00
Affected workers released from corridor to decontamination room ~ 2:10
Nasal Smears sent to HPAL ~ 2:25
NMT-8 & ESH-1 determined initiation of FIC was not required ~ 2:30
ESH-1 notifies ESH-2 and Dose Assessment; ESH-1 Team Leader arrives in the corridor ~ 3:00
F


Lack of a formal reentry plan, plan is required by procedure ESH-1-09-06
Fixed CAM filters changed in an attempt to restore CAMs to operation
Initial contamination survey - highest levels on dry vacuum line, under NW end of glovebox
2 portable CAMs disconnected from airlock and turned on to sample room
Hissing noise identified by RCT-3
Failed to ensure effective communications between various organizations
Missed opportunity to formally implement protocols of the emergency plan
FIC not established
Decontamination needs exceed capability based on number of workers involved
Determination made for all affected workers to go to ESH-2
Escorted by RWS and NMT group leader
F
RCT instructed to muslin cloth the corridor ~3:10
Nasal smear results provided to ESH-1 ~ 3:20
CPT-3 actuates hand/ foot monitor at PF-4 exit - 3:30
Affected workers arrive ESH-1 office for briefing on nasal swipe result ~ 3:30
ET arrives at ESH-2 4:00
First reentry by 3 RCTs without formal re-entry plan ~ 4:00
Furnace in an unaffected glovebox is de-energized ~ 4:10
Facility Rep. notified of occurrence ~ 4:10
G
Failed to ensure effective communications between organizations
Miscommunication between ESH-1 and ESH-2 regarding nature of contamination
No FIC established to control the emergency response
Workers were not escorted by a knowledgeable unaffected responder
Affected workers drive themselves to ESH-2
Adjacent room CAMs returned to service
Local alarm reset on CAMs, contamination caused re-alarm
2nd entry made in SCBA
All 8 exposed workers placed on a bioassay monitoring program
4 workers with highest nasal smear results elect to undergo chelation therapy
ESH-2 provides medical counseling on chelation to the affected workers
Failure to establish an effective formality of operations process
Potential loss of event information and real time event reconstruction
Workers did not provide witness statements nor were they debriefed prior to departure for home
3rd entry placed workers at increased risk of exposure
3rd entry would have been unnecessary if a recovery plan was documented
Entry made in respirator
G
7 affected workers arrive at ESH-2 RCT-1 drives the van 4:15
CT-2 & CT-3 depart ESH-2 4:40
2nd entry CAMs repositioned and all hand monitors secured ~ 5:00
Chelation treatment begins for four most affected workers ~ 5:00
HQ EOC notified 5:13
Affected workers depart ESH-2 5:20
3rd (final) 2 minute entry made by two technicians to listen for hissing sound ~ 5:50
PF4 closed for the night 6:45

APPENDIX C
BARRIER ANALYSIS

Hazard: Airborne Contamination		Target: Worker	
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?**
Radiation hand monitors (Ludlum Model 214)	Not Used	Responded as designed; RCT response to alarm was a missed opportunity.	May have caused an increased severity in the consequences.
Continuous air monitors	Failed	Sampling locations for air monitors not positioned in optimal location for maximum personnel protection.	Repositioning of samplers may have reduced the exposure time of all but one of the workers; minimal impact on the individual with maximum exposure.
Mechanical pipe fitting integrity	Failed	Mechanical compression fitting on the dry vacuum line was not properly tightened during installation.	Failure of the fitting resulted in the release of contamination from internally contaminated piping when argon valve was opened.
Header isolation valves	Failed	Argon header isolation valve was open. Valve operation is prevented by memo only and has limited applicability. There is no valve line-up checklist or policy on valve operation.	Isolation between a contaminated pipe and a pressure source was compromised.
Vacuum manifold valve	Failed	Valve operating surface (Teflonâ) deterio-rated due to thermal, abrasion, and/or radiation damage.	Dry vacuum valve could not isolate argon pressurization of the manifold from the dry vacuum piping and the failed mechanical fitting.
Respiratory Protection Program	Not Used	Potential hazard was not addressed, and appropriate PPE was not utilized.	Lack of respirator resulted in an increase in the total intake by affected workers.
Configuration Control: a) Piping and valves; b) Valve alignment, c) Valve labeling; Operator Aids d) Procedures, piping and electrical drawings, system lineup	Not Used	a) Piping and valves are not installed per Field Change Request. b) System valve alignment is not defined. c) Valves are not labeled for function, or operation; No placards or postings to provide assistance in system operation. d) Piping and electrical drawings are not current to the as built condition of the support systems for the glovebox.	Field design change identified the need for gate valves, thus limiting the pressurization rate of the vacuum line. Proper component identification (labeling) would have identified that the lines being evaluated were not part of the assigned task. Valve labeling would have informed the worker that manifold valves were not for the glovebox. Lack of an operating procedure and a documented valve lineup for the airlock manifold valves may have caused piping pressurization.
Standards, Procedures and Permits – RWP, SWP, SOP, Safety Manual. • Work planning; • Work control	Failed	Procedure TA55-SOP-555.R4, which defines the baseline safety envelope for radiological control at TA-55, was the only work control procedure; it was not adequate for the task, nor was it intended for this work. Skill of worker operations were allowed since no standards existed.	Lack of work planning, hazards analysis, and hazard controls allowed an activity that affected mechanical joints in a contaminated system without proper protection. There is no uniform understanding of what activities are, or are not, allowed under this procedure. A standards or procedure-based approach would have identified the hazards and established controls to limit the risk associated with those hazards which management would have approved. This task relied upon the skill of the workers involved without clear limitations on their actions or an understanding of the consequences of those actions.

Hazard: Airborne Contamination		Target: Worker	
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?**
Training and Qualifications	Failed	Workers did not understand the potential hazards, did not understand system design and operation (purpose of certain valves and piping runs).	Worker's knowledge was not commensurate with the assigned responsibility or with actions taken. More thorough knowledge of piping systems might have prevented the actions taken.
Quality Assurance of Piping Installation	Failed	The piping and components in the manifold were not installed per Field Change Request to minimize overpressurization. There is no documentation that the mechanical compression fittings were tested after installation.	Failure to install the piping in the design configuration contributed to confusion on valve operations. Component changes (as-built vs. as-designed) increased the probability of high pressures affecting the vacuum system piping. Failure to test the mechanical compression fittings allowed an improperly installed fitting to go undetected.
Lessons Learned	Failed	Multiple lessons learned opportunities (ORPS, LANL and TA-55 bulletins, RIRs) were not communicated to the worker level. Previous occurrence evaluations did not determine the direct cause; i.e., source of the contamination, to ensure the proper correctives were developed.	Workers could not benefit from the lessons learned from precursor contamination events; the potential for residual contamination; or the potential for and consequences of shaking piping to look for failed connections. The November 19, 1998, occurrence investigation for the same glovebox did not thoroughly evaluate the source of the contamination, nor identify the leaking mechanical fitting.
Hazard Analysis a) For electrolytic decontamination b) For maintenance evaluation	Failed	a) The electrolytic decontamination hazard analysis for this box was limited to the HA performed for previous glovebox decontamination efforts. The HA did not identify the differences between the Pu-239 and Pu-238 glovebox designs and operations. b) Did not evaluate the possible consequences of pipe shaking or valve operation while evaluating the loss of argon flow to the glovebox.	a) High humidity from decon operations may have shorted the glovebox power receptacle. The resulting trip of the breaker in circuit #10 led to isolation of the solenoid valve in the glovebox argon supply line. Lack of argon flow is what generated the request for a maintenance evaluation. b) Past experience with mechanical joint failures leading to contamination should have resulted in additional hazard controls when shaking piping systems or operating valves.
Technical Basis Documents	Failed	The Facility Hazard Analysis (subset of the SAR) does not analyze the risk (probability and consequence) of either a positive pressure scenario resulting in an airlock or vacuum line leak. The HA does not analyze the risk to workers associated with failures in various auxiliary systems.	Lack of an evaluation of these auxiliary systems limits the knowledge and understanding of the facility in setting operational limits and understanding the consequences of certain accident situations. The release of Pu-238 from the dry vacuum line may have been prevented if this scenario was evaluated.

Hazard: Airborne Contamination		Target: Worker	
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?**
Communications a) Work control b) Troubleshooting activities c) Tripping of circuit #10	Failed	a) AWS and RWS did not communicate unusual conditions associated with the glovebox. b) Scope of the task for the argon flow evaluation was not communicated to the RCT. c) Technicians did not communicate the status of circuit #10 to each other.	Lack of adequate communication did not provide the workers or supervisors with the needed information to properly investigate the failures associated with circuit #10 or argon flow.
System Design	Failed	1) Selection of improper material for valve seats (Teflon®) in a contaminated system. 2) Over reliance on the use of compression fittings.	Valve seat leakage and an incorrectly assembled compression fitting resulted in the release of contamination.

Tables, Figures, and Exhibits

Tables

Figures

Exhibits

Abbreviations Used in This Report

AAMFO	LAAO Assistant Area Manager for Facility Operations
AC	Alternating Current
AL	DOE Albuquerque Operations Office
ALARA	As Low as Reasonably Achievable
Anti-C	Anti-Contamination Clothing
AWS	Area Work Supervisor
CAM	Continuous Air Monitor
CDE	Committed Dose Equivalent
CEDE	Committed Effective Dose Equivalent
CFR	Code of Federal Regulations
CPT	Chemical Process Technician
CT	Chemical Technician
DCP	Design Change Package
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U. S. Department of Energy
DP	DOE Office of the Deputy Administrator for Defense Programs
DTPA	Diethylenetriaminepentaacetate
EH	DOE Office of Environment, Safety and Health
EM&R	Emergency Management & Response
EPA	U. S. Environmental Protection Agency
ESH	Environment, Safety and Health Group
ES&H	Environment, Safety, and Health
ET	Electrical Mechanical Technician
FCR	Field Change Request
FMU	Facility Management Unit
HEPA	High Efficiency Particulate Air
HPAL	Health Physics Analytical Laboratory
ISM	Integrated Safety Management
LAAO	Los Alamos Area Office
LANL	Los Alamos National Laboratory
LIG	Laboratory Implementing Guideline
LIR	Laboratory Implementing Requirement
LPR	Laboratory Procedure Requirement
LRRI	Lovelace Respiratory Research Institute
MOU	Memorandum of Understanding
NMT	Nuclear Material Technology Division
NNSA/DP	National Nuclear Security Administration of the U.S. Department of Energy/ Defense Programs
ORPS	Occurrence Reporting and Processing System
RCT	Radiological Control Technician
RWP	Radiological Work Permit
RWS	Room Work Supervisor
SAR	Safety Analysis Report
SCBA	Self-Contained Breathing Apparatus
SOP	Safe Operating Procedure
SOW	Statement of Work
SWP	Special Work Permit
TA	Technical Area
TEDE	Total Effective Dose Equivalent
TSR	Technical Safety Requirement
UC	University of California